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PACKET SATELLITE COMMUNICATION SYSTEM

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[There are no amendments to this patent.]

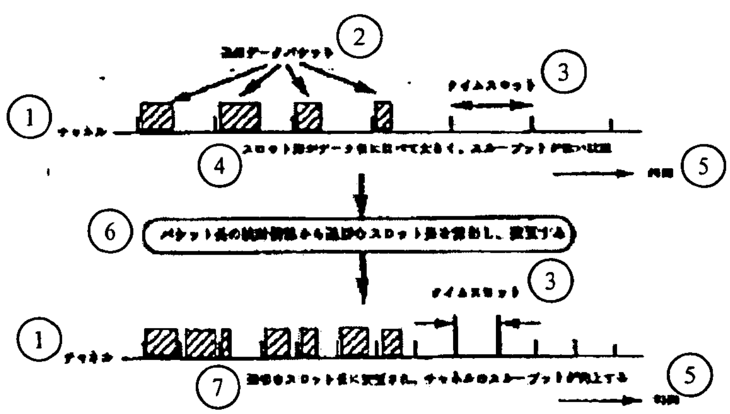
Abstract

Objective

To improve throughput through efficient utilization of slots without altering synchronization during satellite communications using a slotted Aloha system.

Constitution

For satellite communications between a single central station and many peripheral stations using a slotted Aloha system, the central station has a function to obtain and store pieces of information on the number of packets received from the peripheral stations, packet arrival times, and packet lengths, to calculate the average packet length according to statistical information using a weighting method based on the number of packets transmitted by the respective peripheral stations, and to calculate and add a change in the packet [length] over time in order to calculate the best slot length for a given channel condition. While the central station notifies the change in the slot length to the respective peripheral stations via a satellite according to the calculated slot length, because the slot length is calculated in such a manner that a frame length is not changed, and because the slot length is changed dynamically, communication is never interrupted by altered synchronization. The respective peripheral stations generate packets according to the changed slot length and transmit them to the central station.



Keys: 1 Channel
2 Transmitting data packet
3 Time slot
4 Condition in which slot length is longer than data length, and throughput is low
5 Time
6 An appropriate slot length is calculated based on statistical information on packet length to change [the current slot length]
7 Channel throughput is improved as changing to the appropriate slot length occurs

Claims

1. A packet satellite communication system characterized in that in a packet satellite communication system configured with a single central station and many peripheral stations arranged in a star shape which utilizes a slotted Aloha system, in which the respective peripheral stations use a common channel for data transmission during communications from the peripheral stations to the central station via a satellite, and which utilizes a broadcast type channel capable of communicating with all the peripheral stations from the central station via the satellite, the central station stores pieces of information on the number of packets received from the peripheral stations, packet arrival times, and packet lengths in succession, calculates the average packet length according to statistical information using a weighting method based on the number of packets transmitted by the respective peripheral stations, adds a change in the packet length over time so as to calculate the best slot length for a given channel condition, and notifies the change in the slot length to the respective peripheral stations via the satellite in order to change the slot length automatically without altering synchronization.

2. A central station in a packet satellite communication system characterized in that it is a central station in a packet satellite communication system configured with a single central station and many peripheral stations arranged in a star shape which utilizes a slotted Aloha system, in which the respective peripheral stations use a common channel for data transmission during communications from the peripheral stations to the central station via a satellite, and which utilizes a broadcast type channel capable of communicating with all the peripheral stations from the central station via the satellite; and it has a means which stores pieces of information on the number of packets received from the peripheral stations, packet arrival times, and packet lengths in succession, a means which calculates the average packet length according to statistical information using a weighting method based on the number of packets transmitted by the respective peripheral stations, a means which adds a change in the packet length over time so as to calculate the best slot length for a given channel condition, and a means which notifies the change in the slot length to the respective peripheral stations via the satellite in order to change the slot length automatically without altering synchronization.

Detailed explanation of the invention

[0001]

Industrial application field

The present invention pertains to a multiple access packet satellite communication system in which communications between a single central station and many peripheral stations are carried out using a single channel via a satellite. More specifically, it pertains to a packet

satellite communication system in which a time division multiple access (TDMA) system is used for gaining channel access from the peripheral stations to the central station.

[0002]

Prior art

As shown in Figure 1, the most basic configuration of a packet satellite communication system involves a single central station and many peripheral stations communicating via a satellite. In the case of the star shaped configuration shown in Figure 1, while a time division multiplex (TDM) system with a broadcast type channel is utilized when transmitting a packet from the central station to the peripheral stations, a multiple access system in which multiple peripheral stations utilize a single common communication channel is mainly used for transmissions from the peripheral stations. In addition, in terms of the channel access system, because transmitting data are often short and transmitted in bursts, a random access system in which a packet is transmitted every time a set of data is generated is utilized. In the case of said random access system, because the respective peripheral stations transmit data randomly, data may be lost due to collision between data. Therefore, a packet retransmission function is needed, and a slotted Aloha system as a type of random access system has been adopted in order to minimize the probability of collisions.

[0003]

Said slotted Aloha system has long been utilized for satellite communications which are subject to large transmission delays in order to achieve a high throughput. The maximum throughput of said slotted Aloha system is approximately 37%, a throughput twice as high as that of a pure Aloha system. However, the throughput during an actual communication tends to be lower than said value. This occurs because the length of the packets generated for transmitting many small sets of data is shorter than the slot length and only 1 packet can be put in 1 slot, so that a blank is created within the slot, resulting in waste during transmission. In order to alleviate the drop in throughput due to said disadvantages, Japanese Kokai Patent Application No. Sho 63[1988]-228832 suggests a method in which the slot length is changed dynamically in response to a request from the central station. In addition, a method in which the actual channel condition is observed, and the slot length is calculated as needed based on said information in order to generate said slot length change request dynamically has been suggested. For example, a method in which the condition of channel use is monitored, and the resulting information is stored is described in Japanese Kokai Patent Application No. Sho 58[1983]-219838, and a preassignment system provided with a function to aggregate the amount of communications by the peripheral stations while utilizing a channel access system other than the random access system is described

in Japanese Kokai Patent Application No. Hei 4[1992]-312029. A system in which the peripheral stations and the central station observe the channel condition so as to check the distribution of packet length, a frame is divided into slots of various lengths in advance based on said distribution, and a peripheral station selects a slot with the most suitable length for a given packet to be transmitted among said [slots] and inserts the packet therein for transmission is described in Japanese Kokai Patent Application No. Hei 2[1990]-181527. In addition, as a method for filling a blank created in a slot at the time of data transmission, a method in which multiple packets are joined together and inserted into a single slot for transmission is suggested in Japanese Kokai Patent Application No. Hei 1[1989]-200739.

[0004]

Methods for improving the throughput are suggested also from the viewpoint of reducing the probability of collision between packets in the random access system. For example, Japanese Kokai Patent Application No. Sho 62[1987]-157428 and Japanese Kokai Patent Application No. Sho 62[1987]-199129 suggest methods in which when data to be transmitted contain relatively many large data sets, and a large data set has to be transmitted in packets, the random access system is switched to a reservation system in which slot allocation is reserved.

[0005]

Problems to be solved by the invention

In the case of a conventional slotted Aloha system, the slot length shown in Figure 2 is set to an appropriate length prior to the beginning of a communication based on a predicted data length and traffic, and it is fixed throughout the communication. In addition, only 1 packet can be inserted in each slot. Therefore, when packets smaller than the slot length are transmitted often, the transmission of information results in a waste in that only a portion of the slot is utilized for communication. That is, there is a problem that the throughput in such case ends up being diminished. In addition, if the slot length is set shorter than transmitting data when a large data set is transmitted often, the data to be transmitted have to be transmitted in multiple packets, resulting in another problem that it takes more transmission time than when it is transmitted at one time. Therefore, a slot length suitable for the channel condition must be set in order to generate a packet with a length that is effective for the actual transmission. Furthermore, because the length of transmitting data changes over time according to the type, the slot length needs to be changed accordingly.

[0006]

Although the methods described under prior art have been suggested in order to solve these problems, they still contain problems yet to be taken into consideration. First, although the synchronization is also to be altered as the slot length is changed dynamically during communication in the case of Japanese Kokai Patent Application No. Sho 63[1988]-228832, this is impossible since in reality the communication is most likely to be interrupted if the synchronization is altered dynamically during the communication. In addition, when a variety of slot lengths is involved as is evident in the method described in Japanese Kokai Patent Application No. Hei 2[1990]-181527, the intervals between the positions of unique words (sync control signals) within the frame become the same, making it difficult to sustain synchronization. In addition, if each peripheral station is to select a slot with an appropriate length within said [frame], not only does the selection take time, but the probability of a collision between packets also increases, so that the throughput drops. Although the problem of an increased collision probability can be avoided when the preassignment system described in Japanese Kokai Patent Application No. Hei 4[1992]-312029 is adopted as a method for varying the slot length, because all peripheral stations have to be able to access 1 slot in the case of the random access system, the slot length needs to be fixed. That is, a method for changing the slot length dynamically has to be adopted under the requirements that the slot length is uniform within the frame and that because the synchronization among the peripheral stations is established based on the unique words within the frame transmitted from the central station, the frame length must also remain constant so that synchronization will not be lost.

[0007]

Therefore, the objective of the present invention is to present a packet satellite communication system in which a frame length is divided uniformly without altering synchronization, that is, without changing the frame length, and the best slot length for a given channel condition is calculated so as to utilize the slots efficiently in order to improve the throughput.

[0008]

Means to solve the problems

With the present invention, a packet satellite communication system can be obtained which is characterized in that in a packet satellite communication system configured with a single central station and many peripheral stations arranged in a star shape which utilizes a slotted Aloha system, in which the respective peripheral stations use a common channel for data transmission during communications from the peripheral stations to the central station via a

satellite, and which utilizes a broadcast type channel capable of communicating with all the peripheral stations from the central station via the satellite, the central station stores pieces of information on the number of packets received from the peripheral stations, packet arrival times, and packet lengths in succession, calculates the average packet length according to statistical information using a weighting method based on the number of packets transmitted by the respective peripheral stations, adds a change in the packet length over time so as to calculate the best slot length for a given channel condition, and notifies the change in the slot length to the respective peripheral stations via the satellite in order to change the slot length automatically without altering synchronization.

[0009]

With the present invention, a central station in a packet satellite communication system can be obtained which is characterized in that it is a central station in a packet satellite communication system configured with a single central station and many peripheral stations arranged in a star shape which utilizes a slotted Aloha system, in which the respective peripheral stations use a common channel for data transmission during communications from the peripheral stations to the central station via a satellite, and which utilizes a broadcast type channel capable of communicating with all the peripheral stations from the central station via the satellite; and it has a means which stores pieces of information on the number of packets received from the peripheral stations, packet arrival times, and packet lengths in succession, a means which calculates the average packet length according to statistical information using a weighting method based on the number of packets transmitted by the respective peripheral stations, a means which adds a change in the packet length over time so as to calculate the best slot length for a given channel condition, and a means which notifies the change in the slot length to the respective peripheral stations via the satellite in order to change the slot length automatically without altering synchronization.

[0010]

As described above, in the present invention, the central station has a function to obtain and store the number of packets transmitted from the peripheral stations, their arrival times, and packet lengths as statistical information, to calculate the average packet length first according to said pieces of information using an algorithm for weighted averaging based on the number of the packets transmitted from the respective peripheral stations, and to calculate the best slot length for the actual channel condition while taking change in the packet length over time into consideration in order to change the slot length automatically as needed. In addition, synchronization is not altered in order to prevent interruption of the communication due to an

alteration of the synchronization. In other words, the central station has a function to change only the length and the number of slots that are divided in the frame without changing the frame length to obtain the most suitable situation for a given channel condition in order to keep a fixed interval between unique words inserted into the beginning of the frame.

[0011]

Due to the aforementioned function, the necessary change for switching to the best slot length for the channel condition can be made automatically as needed according to the average length of a packet inserted into a slot and its change over time, and slots can be utilized efficiently as a result, so that the throughput can be improved.

[0012]

Application example

An application example of the present invention will be explained in reference to figures.

[0013]

Figure 1 is a diagram of the overall configuration of a packet satellite communication system pertaining to an application example of the present invention. As shown in Figure 1, said packet satellite communication system is configured with a single central station 1 and many peripheral stations 3 arranged in a star shape via satellite 2. A time division multiplexing (TDM) system utilizing a broadcast type channel is used for transmission from central station 1 to peripheral stations 3. On the other hand, because transmitting data are often short and transmitted in bursts from peripheral stations 3 to central station 1, a time division multiple access system in which respective peripheral stations 3 share a single communication channel is adopted. A random access system as one type of said time division multiple access system in which a data packet is sent out to the channel every time a set of transmitting data is generated is used. Furthermore, because data are transmitted from respective peripheral stations 3 relatively frequently, a slotted Aloha system as one type of random access system is used in order to minimize the probability of a collision between packets.

[0014]

First, configurations of the stations of the packet satellite communication system will be explained. Central station 1 is configured in the manner shown in Figure 3. In Figure 3, upon receiving a signal from a peripheral station through antenna 13, the central station carries out data reception processing at reception part 12. The processed signal is output to receiving data buffer 9 and fetched as receiving data. In the meantime, arrived packet information is checked

and stored in succession by successive statistical information storage part 10, and the stored information is output to slot length calculation part 11 when the total number of arrived packets has reached a prescribed value. Slot length calculation part 11 sets a slot length appropriate for the channel condition based on said information and sends a request to control signal generating part 8 to make a change. Timing signal generating part 4 generates a signal indicating divisions of a frame comprising prescribed slots in order to achieve synchronization with the peripheral stations. Control signal generating part 8 generates a reception response signal upon receiving an output from aforementioned reception part 12, and it also generates a control signal used to notify the peripheral stations of the reception of the slot length change request from slot length calculation part 11 and sends it to multiplexing part 6. Multiplexing part 6 multiplexes transmitting data sent via transmitting data buffer 5, the control signal sent from control signal generating part 8, and the timing signal sent from timing signal generating part 4 and outputs [the resulting signal] to transmission part 7. Electric waves for the data transmitted through antenna 13 upon receiving the output of transmission part 7 are relayed by satellite and carried to the respective peripheral stations.

[0015]

Figure 4 shows the configuration of the peripheral stations. When data are received through antenna 22 at a peripheral station, they are output to receiving data buffer 21 after processing by reception part 20 and are fetched as receiving data. In addition, for data received through antenna 22, a sync signal is output to frame sync part 18 in order to achieve synchronization with the central station. For control signals, a retransmission request signal, for example, is sent to retransmission control part 19, and a control signal requesting change in the slot length is output to transmitting slot management part 17 and is used to set the slot length. After transmitting data are buffered once into transmitting data buffer 16, they are sent to multiplexing part 15, the data are divided into packets according to a request from transmitting slot management part 17 in order to multiplex the respective signals, and [the resulting signal] is output to the central station through antenna 22 via transmission part 14. When a retransmission request is received, retransmission control part 19 notifies transmitting data buffer 16 of said fact in order to have data retransmitted.

[0016]

Next, detailed operation will be explained. While an appropriate slot length is set at the central station in advance before the communication begins based on a predicted data length and traffic, [the central station] is set to change it to a slot length suitable for the channel condition according to statistical information on packet length obtained once the communication has begun.

As shown in Figure 5, statistical information storage part 10 in the central station in Figure 3 is configured with memory 24 for storing information, packet arrival detection circuit 27 for constant monitoring of packet arrivals, clock circuit 23 for determining arrival times, packet length measurement circuit 26 for measuring packet lengths, and statistical information control circuit 25 for controlling the memory. In addition, slot length calculation part 11 in Figure 3 is configured with information buffer 28 for buffering information output from memory 24, information aggregation circuit 29 for aggregating said information, slot length calculation circuit 30 for calculating a slot length suitable for the channel based on said [information] using a weighted averaging algorithm based on the number of packets to be described later, and slot length change request circuit 31 for instructing control signal generating part 8 to generate said slot length and a change request signal. Packet arrival detection circuit 27 monitors reception part 12 constantly, and as soon as it detects the arrival of a packet, it checks for which peripheral station is the source. Furthermore, its arrival time is determined by clock circuit 23, and the packet length is measured by packet length measurement circuit 26. The respective pieces of information obtained through these measurements regarding the originating peripheral station of the packet, its arrival time, and the packet length are stored in memory 24 under the control of statistical information control circuit 25. Statistical information control circuit 25 manages the number of packets accumulated in memory 24 and instructs memory 24 to output them to information buffer 28 once the total number has reached a prescribed value. After said pieces of information are stored in information buffer 28 once, they are aggregated by information aggregation circuit 29, and an appropriate slot length is calculated accordingly by slot length calculation circuit 30 using a weighted averaging algorithm to be described later.

[0017]

A method for calculating the best slot length for the channel condition based on the aforementioned statistical information will be described below. First, the number of packets that have arrived at the central station, respective packet lengths, and their arrival times are aggregated for each peripheral station. Then, the average value of the packet lengths of all the packets is obtained. Here, because the number of packets transmitted by the respective peripheral stations vary, all the peripheral stations are averaged using the number of packets transmitted by the respective peripheral stations for weighting after the average packet length of each peripheral station is calculated. That is, assuming that given station Ai has transmitted ai units of packets, and their average value is mi, average value M of the packet lengths from all the peripheral stations when weighted using ai is expressed by Formula 1 given below.

[0018]

Formula 1

$$M = \frac{\sum_{i} a_i m_i}{\sum_{i} a_i}$$

[0019]

Here, when the arrival times of respective packets from peripheral stations A_i are t_{ij}, and the packet lengths are $P_{ij} = P(t_{ij})$, m_i takes the value expressed by Formula 2 given below.

[0020]

Formula 2

$$m_i = \frac{\sum_{j} P_{ij}}{a_i}$$

[0021]

The weighted averaging method in Formula 1 is adopted in order to incorporate the conditions of the channel use by the respective peripheral stations, that is, the distribution of the number of packets per each peripheral station, into the calculation of the average value of the lengths of packets from all the peripheral stations. When this kind of averaging method is adopted, slot lengths more suitable for the actual channel conditions can be derived.

[0022]

Furthermore, the length of packets transmitted by the respective peripheral stations are not constant, and they change moment by moment according to the type of data transmitted. Thus, a rate of change over time is obtained for each of the aggregated peripheral stations. This allows flexible coping with changes in the channel condition over time. First, assuming that the time at which memory 24 outputs information to information buffer 28 is t_e, and the previous output time is t_s, statistical information is aggregated during the period given below.

[0023]

Formula 3

$$\Delta t = t_e - t_s$$

[0024]

Assuming that the time required for communication from a peripheral station to the central station is t_R, time-based changing rate D_i in terms of the length of packet A_i transmitted in a unit of time can be obtained by Formula 4 given below.

[0025]

Formula 4

$$D_i = \frac{dP(t - t_R)}{dt}$$

[0026]

Here, $t = t_{ij} - t_s$. D_i indicates the time-based changing rate within time Δt. Thus, like the packet length, when its weighted average is calculated using the number a_i of packets transmitted by the respective peripheral stations, average time-based changing rate D in the channel packet length can be expressed by Formula 5 given below.

[0027]

Formula 5

$$D = \frac{\sum_i a_i D_i}{\sum_i a_i}$$

[0028]

If said value is negative, it means that the packet length is becoming shorter as time passes, and the packet length is becoming longer as time passes if it is positive. Assuming that the next statistical information is aggregated within the same time Δt, and the same time-based changing rate is realized, [the value] obtained by adding [the value] obtained by multiplying said time-based changing rate D by Δt to the average value calculated using Formula 1 becomes subsequent channel average packet length P as expressed by Formula 6.

[0029]

Formula 6

$$P = M + D \cdot \Delta t$$

[0030]

As already described above, because the frame length is fixed for the sake of synchronization and is divided by the same slot length, it is preferable that the frame length be an integer multiple of the slot length. Thus, when the frame length is F, Formula 7 given below can be obtained.

[0031]

Formula 7

$$S=\frac{F}{INT\ (F/P)}$$

[0032]

Here, INT (F/P) indicates that the value of (F/P) is converted into an integer. S calculated in said manner becomes the slot length to be obtained. Upon receiving slot length S calculated by aforementioned slot length calculation circuit 30 and the output of a request for changing it, slot length change request circuit 31 instructs control signal generating part 8 to generate a slot length change request signal, insert this control signal into the slot length change request field within the control field of the time division frame shown in Figure 6, and send it to the respective peripheral station via the satellite. Each peripheral station checks the slot length change request part placed in said control field using transmitting slot management part 17, controls the slot length along with the frame sync signal, divides the data according to said slot length, creates a packet, and transmits it.

[0033]

Effect of the invention

As explained above, in the case of a packet satellite communication system in accordance with the present invention, because the average packet length is calculated using a method in which the channel condition is monitored, and weighted averaging is applied using the number of packets transmitted by the respective peripheral stations based on the packet information transmitted by the respective peripheral stations, the best slot length for the channel condition is calculated by adding the time-based changing rate of the packet length to the slot length, and the slot length is reset automatically accordingly in order to reduce an unused part, that is a wasted part, within a slot during the transmission of a small packet. An effect is thus obtained in that the channel throughput can be improved.

Brief description of the figures

Figure 1 is a diagram showing the overall configuration of a packet satellite communication system pertaining to an application example of the present invention.

Figure 2 is a diagram for explaining an example of the function of the packet satellite communication system in Figure 1.

Figure 3 is a block diagram of a central station used for the implementation of the packet satellite communication system in Figure 1.

Figure 4 is a block diagram of a peripheral station used for the implementation of the packet satellite communication system in Figure 1.

Figure 5 is a block diagram of the statistical information storage part and the slot length calculation part contained in the central station in Figure 3.

Figure 6 is a diagram for explaining the format of a transmitting frame from the central station.

Explanation of symbols

1	Central station
2	Satellite
3	Peripheral station
4	Timing signal generating part
5, 16	Transmitting data buffer
6, 15	Multiplexing part
7, 14	Transmission part
8	Control signal generating part
9, 21	Receiving data buffer
10	Statistical information storage part
11	Slot length calculation part
12, 20	Reception part
13, 22	Antenna
17	Transmitting slot management part
18	Frame sync part
19	Retransmission control part
23	Clock circuit
24	Memory
25	Statistical information control circuit
26	Packet length measurement circuit
27	Packet arrival detection circuit

28 Information buffer
29 Information aggregation circuit
30 Slot length calculation circuit
31 Slot length change request circuit
32 Frame pattern
33 Reception response field
34 Control information field
35 Slot length change request field
36 Number of slots per 1 frame

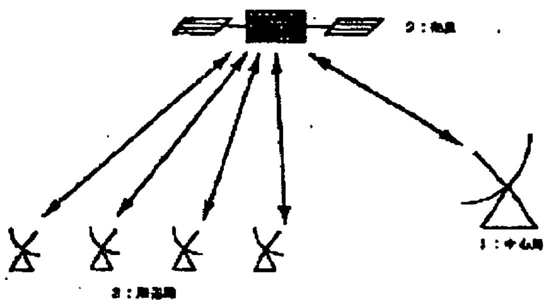


Figure 1

Key:
1 Central station
2 Satellite
3 Peripheral station

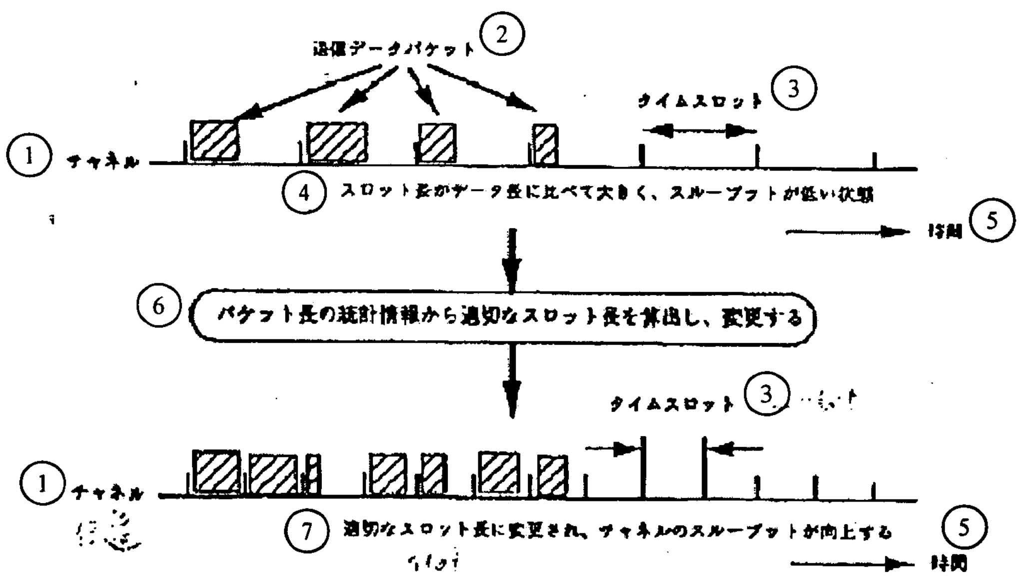


Figure 2

Key:
1 Channel
2 Transmitting data packet
3 Time slot
4 Condition in which slot length is longer than data length, and throughput is low
5 Time
6 An appropriate slot length is calculated based on statistical information on packet length to change [the current slot length]
7 Channel throughput is improved as changing to the appropriate slot length occurs

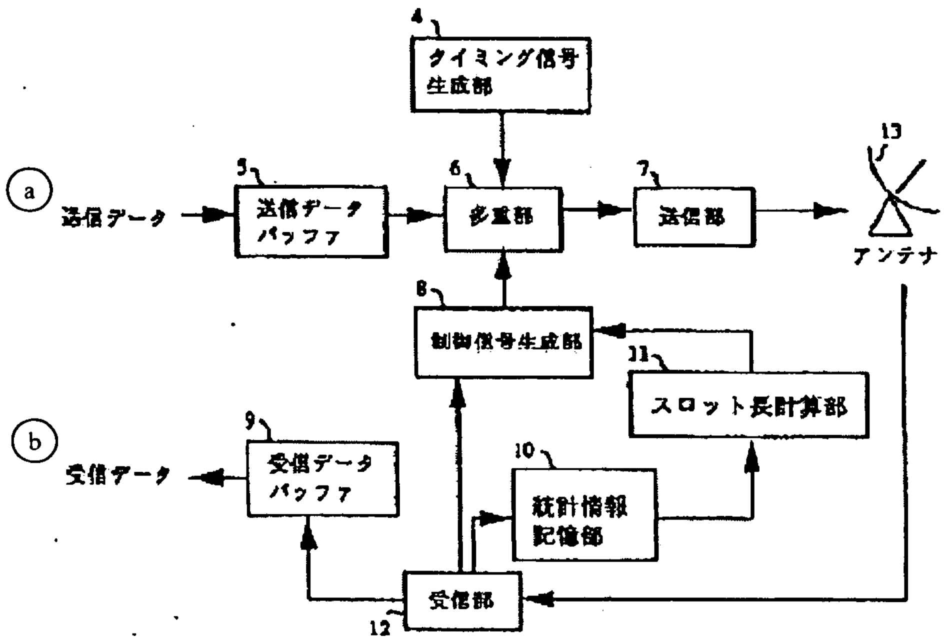


Figure 3

Key:
a Transmitting data
b Receiving data
4 Timing signal generating part
5 Transmitting data buffer
6 Multiplexing part
7 Transmission part
8 Control signal generating part
9 Receiving data buffer
10 Statistical information storage part
11 Slot length calculation part
12 Reception part
13 Antenna

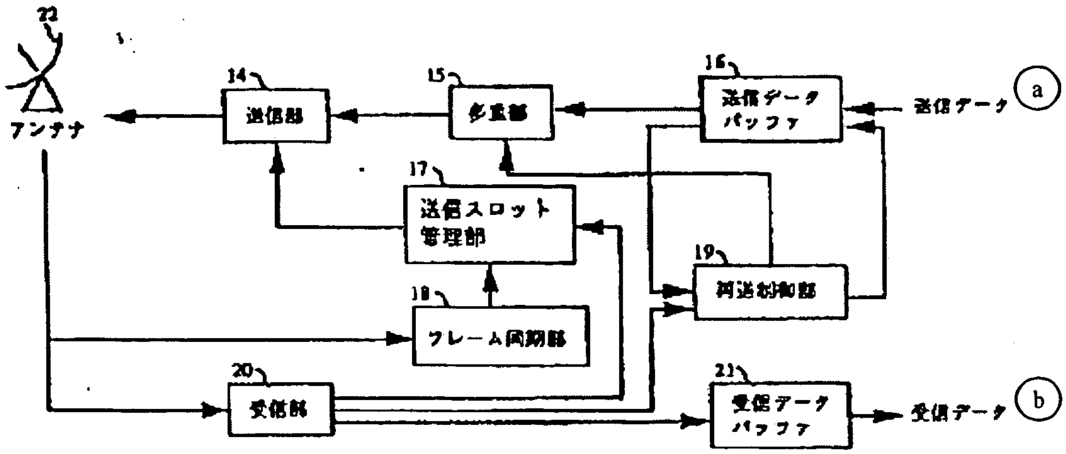


Figure 4

Key:
- a Transmitting data
- b Receiving data
- 14 Transmission part
- 15 Multiplexing part
- 16 Transmitting data buffer
- 17 Transmitting slot management part
- 18 Frame sync part
- 19 Retransmission control part
- 20 Reception part
- 21 Receiving data buffer
- 22 Antenna

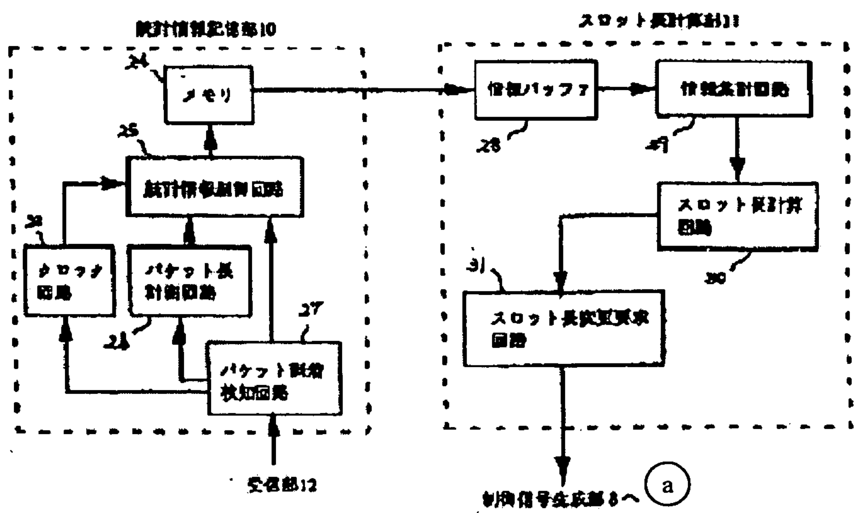


Figure 5

Key: a To control signal generating part 8

10 Statistical information storage part
11 Slot length calculation part
12 Reception part
23 Clock circuit
24 Memory
25 Statistical information control circuit
26 Packet length measurement circuit
27 Packet arrival detection circuit
28 Information buffer
29 Information aggregation circuit
30 Slot length calculation circuit
31 Slot length change request circuit

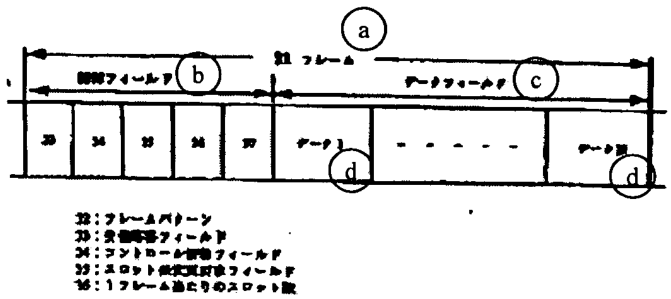


Figure 6

Key:		
	a	32 frames
	b	Control fields
	c	Data fields
	d	Data ___
	32	Frame pattern
	33	Reception response field
	34	Control information field
	35	Slot length change request field
	36	Number of slots per 1 frame